Siamese Crocodile Crocodylus siamensis

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Common Names: Siamese crocodile (English), Buaya Kodok, Buaya Siam, Buaya Badas Hitam (Indonesia), Jara Kae Numchued (Thailand), Kropeu (Cambodia), 'Ke'/'Kae' (Laos and Thailand), 'Rabur' (local name of Mangkong, Ta Oy and Ka Tong ethnic groups in southern Laos), Cá sau xiêm (Vietnam)

Range: Cambodia, Thailand, Laos, Vietnam, Indonesia (Kalimantan, Java?), Malaysia (formerly?), Myanmar (?)



Figure 1. Distribution of Crocodylus siamensis.

Conservation Overview

CITES: Appendix I

CSG Action Plan:

- Availability of survey data: Poor in most Range States, moderate for Cambodia, Laos and Indonesia
- Need for wild population recovery: Highest
- · Potential for sustainable management: Low to Moderate

<u>2018 IUCN Red List</u>: Critically Endangered (Severe decline in numbers and area, >80% decline in three generations; IUCN 2018) (last assessed in 2012; Bezuijen *et al.* 2012).

<u>Principal threats</u>: Habitat loss, poaching, direct persecution where perceived as threat to humans and livestock, incidental take in fishing gear, illegal trade to stock crocodile farms, populations small and isolated.

Ecology and Natural History

Crocodylus siamensis is a medium-sized crocodilian; males reportedly attain a total length of 4.0 m, although most individuals do not exceed 3.5 m (Smith 1919; Brazaitis 1973a,b). Adults are dark olive, yellowish, or brownish-green to black with dark cross-banding on the tail; the ventral surface is yellowish-white (Brazaitis 1973b). The squamosals form a pronounced bony ridge with another ridge extending anteriorly between the orbits (Fig. 2). *Crocodylus siamensis* is readily distinguished from the broadly sympatric estuarine crocodile (*C. porosus*) in having four enlarged post-occipital scales (Fig. 3), and small irregular scales clustered around the vent and extending along the midline of the ventral surface of the tail (Fig. 4; Brazaitis 1973a,b). Scalation of *C. siamensis* is described in greater detail elsewhere (Smith 1919; Brazaitis 1973a,b; Ross 1990; Bezuijen *et al.* 2013).

The Siamese crocodile occurs in a wide range of freshwater habitats, including slow-moving rivers and streams, lakes, seasonal oxbow lakes, marshes, swamplands, and on occasion, swift-flowing upland streams (Smith 1931; Daltry *et al.* 2003; Bezuijen *et al.* 2006b; Cox and Phothitay 2008; Kanwatanakid-Savini *et al.* 2012; Sam *et al.* 2015). During the wet season, individuals disperse across flooded landscapes (eg radio-tracked individuals have moved up to 25 km before returning to dry season sites; Simpson *et al.* 2006b). The use

Platt, S.G., McCaskill, L., Rainwater, T.R., Temsiripong, Y., As-singkily, M., Simpson, B.K. and Bezuijen, M.R. (2019). Siamese Crocodile *Crocodylus siamensis. In* Crocodiles. Status Survey and Conservation Action Plan. Fourth Edition, ed. by S.C. Manolis and C. Stevenson. Crocodile Specialist Group: Darwin. 13pp.



Figure 2. Siamese crocodile. Note the prominent squamosal ridges behind each eye.



Figure 3. Siamese crocodile (Lao Zoo).



Figure 4. Irregular scale groups on the ventral surface of the tail are characteristic of *Crocodylus siamensis*.

of burrows excavated into the banks of rivers or lakes has been reported with up to five individuals sharing a single burrow (Simpson *et al.* 2006b). Generally preferring lowland elevations, the species has been recorded up to 600 m (Daltry *et al.* 2003; Sam *et al.* 2015).

Nesting occurs at the end of the dry season (March-April) or early wet season (May-June), with females constructing

a mound nest on mats of floating vegetation or along the banks of lakes and rivers (Bezuijen *et al.* 2013; Sam *et al.* 2015). Early reports that *C. siamensis* excavates hole nests in deep sand (Smith 1931; Brazaitis 1973b) are now considered erroneous. Nest mounds are often constructed in deep shade beneath a thick tree canopy.



Figure 5. Siamese crocodile nest constructed on a floating mat (Savannakhet Province, Laos).

Hatchlings emerge in the wet season after 70-80 days of incubation, usually during May-August. Nest site fidelity appears common in some populations (Simpson *et al.* 2006a). Wild clutches found in Cambodia, Laos and Vietnam contained up to 60 eggs (Siah 1957; MOSTE 1992; Simpson and Han 2004; Bezuijen *et al.* 2006b; Platt *et al.* 2006; Cox and Phothitay 2008; Platt 2012; Bezuijen *et al.* 2013; Sam *et al.* 2015). Clutches of up to 50 eggs have been deposited by captive females in Thailand (Youngprapakorn *et al.* 1971). Mean (±1 SD) egg length, width and mass from a sample of 515 eggs in Cambodia were 78.2 ± 4.9 mm, 48.1 ± 2.5 mm, and 90.8 ± 16.5 g, respectively (Platt *et al.* 2011).



Figure 6. Female Siamese crocodile aggressively guarding nest in Savannakhet Province, Laos.

Double clutching reportedly occurs among females in captivity, perhaps due to enhanced nutritional status (Thouk 1995; Whitaker 2008; Platt *et al.* 2011). Nests containing

clutches of non-viable and presumably infertile eggs are reported from Thailand and Laos (Kanwatanakid-Savini *et al.* 2012; Bezuijen *et al.* 2013; Platt *et al.* 2014b) suggesting a paucity of males in some populations. Aggressive nest defense by females is known to occur in some populations (Fig. 5), but overall appears rare (Platt 2012; Bezuijen *et al.* 2013). Provisioning of hatchlings by male and female parents has been observed in captivity (Brueggen 2001; Whitaker 2007). One study estimated first year survival of offspring in the wild at 22% (Sam *et al.* 2015).

Similar to most crocodilians, *C. siamensis* is a dietary generalist that consumes a wide variety of prey such as invertebrates, amphibians, reptiles, birds and mammals (Daltry *et al.* 2003; Bezuijen 2010; Sam *et al.* 2015). Wild pigs (*Sus scrofa*) are the largest reported prey, but most likely were taken as carrion (Sam *et al.* 2015). Although not well-studied, *C. siamensis* probably exhibits the ontogenetic dietary shift typical of crocodilians (eg Platt *et al.* 2006; Wallace and Leslie 2008) with smaller size-classes consuming mostly invertebrates and larger individuals taking increasing amounts of vertebrate prey. Siamese crocodiles are not considered a threat to humans and anthrophagy is non-existent to extremely rare (CrocBite 2018).



Figure 7. Siamese crocodile feces found at a wetland in Savannakhet Province, Laos. Fecal material can provide information on diet.

Information is available on *C. siamensis* phylogeography and population genetics (Gratten 2003), seasonal sperm cycles (Kitiyanant *et al.* 1994) and the antimicrobial properties of its blood (Merchant *et al.* 2006). Hybridization of *C. siamensis* with Cuban crocodiles (*C. rhombifer*) and estuarine crocodiles (*C. porosus*) is known to occur on farms in Southeast Asia and threatens the genetic integrity of some captive stocks (Youngprapakorn *et al.* 1971; Suvanakorn and Youngprapakorn 1987; Chavananikul *et al.* 1994; Thang 1994; Fitzsimmons *et al.* 2002). The chromosome number of *C. siamensis* and hybrids, as well as molecular methods to distinguish hybrids from pure *C. siamensis*, have been identified (Youngprapakorn 1991; Fitzsimmons *et al.* 2002). Hybrid offspring are fertile and capable of reproducing when mature (Sam *et al.* 2015). Methods of assessing and monitoring wild Siamese crocodile populations are available in Simpson (2006) and Platt *et al.* (2014a).

Conservation and Status

Crocodylus siamensis is one of the world's most endangered crocodilians (Ilhow et al. 2015). In 1992 C. siamensis was considered virtually extinct in the wild (Thorbjarnarson 1992) and in 1996 it was listed as Critically Endangered on the IUCN Red List. Subsequently, hitherto unknown wild populations were discovered (eg Cambodia, Laos, and Indonesia) leading to conservation actions. Historically, C siamensis was widely distributed across mainland Southeast Asia, and on some islands of Indonesia and Malaysia. The current global distribution of C. siamensis is much diminished and fragmented, with populations reduced to approximately 20% of the historic distribution (Ilhow et al. 2015). Only 11% of the remaining C. siamensis habitat is encompassed within the national protected area systems of the respective Range States (Ilhow *et al.* 2015). For the most part, remnant C. siamensis populations consist of small numbers of individuals and very few populations are considered reproductively viable. Globally, the primary drivers of endangerment appear to be habitat destruction, direct persecution, and harvesting to stock commercial crocodile farms (Platt et al. 2004; Ilhow et al. 2015). Below we review the conservation status of C. siamensis in each Range State.

· Cambodia: Extensive conservation efforts have been initiated since publication of the 1998 and 2010 CSG Action Plans, including nation-wide population surveys and a long-term field conservation project implemented by the Forestry Administration and Fauna & Flora International (Sam et al. 2015). Field studies began in the late 1990s, following earlier reports suggesting the species was widespread and relatively abundant (Thuok and Tana 1994). Systematic assessments have been completed of many major waterways and likely crocodile habitats (Daltry and Chheang 2000; Daltry et al. 2003; Platt et al. 2004; Simpson and Han 2004; Platt et al. 2006; Simpson et al. 2006a; Timmins 2007; Bezuijen et al. 2009; Sam et al. 2015). These surveys confirmed the presence of C. siamensis from 35 sites on 21 river systems in 11 provinces, but indicate surviving populations are depleted and fragmented. Many populations are outside of protected areas and contain only one or two individuals. The total wild population of C. siamensis in Cambodia could comprise fewer than 150 adults (Cambodian Crocodile Conservation Programme database; reviewed by Sam et al. 2015).

Although populations are small and highly fragmented, overall numbers appear stable (Frechette *et al.* 2016). Important riverine and wetland systems for crocodile conservation include the Srepok, Sekong, Sre Ambel, Pursat, Koi, Kep, Tatai and Areng Rivers, Veal Veng Marsh, and Tonle Sap (= Great Lake) Biosphere Reserve. Freeliving hybrids (*C. siamensis* × *C. porosus* and *C. siamensis* × *C. rhombifer*) appear established in some parts of the Tonle Sap Biosphere Reserve, and presumably originated from crocodiles that escaped from floating farms on the lake (Mahood *et al.* 2015).

Since 2001, nesting has been recorded at 10 locations in 8 provinces, however threats continue to reduce breeding success, and the number of active nest sites is declining (Simpson et al. 2006a). Veal Veng Marsh and the Areng River, both in the Cardamom Mountains, are thought to harbor the largest wild populations, with one to three nests being produced annually at each site. Veal Veng Marsh and the Areng and Sre Ambel Rivers are now the focus of enforcement patrols and community-based conservation management, which have demonstrated success in reducing poaching (Daltry et al. 2006; Simpson and Ratanapich 2007; Simpson et al. 2006). Additional community sanctuaries are planned in the northeast. A small captive breeding program has been established at Phnom Tamao Wildlife Rescue Center near Phnom Penh to produce offspring for reintroduction at suitable sites (Starr et al. 2009; Frechette et al. 2016). At the time of this writing (late 2017), 68 captive-bred, head-started C. siamensis had been released into the wild (Frechette et al. 2016; Manolis 2017).

Human activities continue to impact most C. siamensis populations in Cambodia. Many river systems, including those in protected areas, have hydroelectric power dams proposed, approved or under development, which could potentially result in the loss of half of the remaining breeding colonies within the next 10 years. That said, hydropower impoundments, if properly managed, can support breeding populations of crocodilians (eg Somaweera and Shine 2013). Cambodia has more than 900 crocodile farms, mostly situated around the Tonle Sap (Jelden et al. 2005). According to Sovannara (2011), the captive population of C. siamensis and hybrids numbered at least 257,000 in 2010. Illegal capture of wild crocodiles to supply farms is a continuing threat, as well as incidental capture/drowning in fishing nets and traps and habitat loss (SCWG 2004; Platt et al. 2005).

Despite ongoing conservation efforts, the long-term viability of remnant populations throughout Cambodia is uncertain. The Cambodian Government in collaboration with conservation groups has initiated a reintroduction plan to augment and secure the viability of wild populations (Sam *et al.* 2015; Frechette *et al.* 2016; Eam *et al.* 2017). Efforts to engage the crocodile farming industry in conservation through captive breeding and reintroduction will no doubt prove crucial in meeting long-term objectives (Frechette *et al.* 2016). Crocodile farmers recently offered to provide up to 200 *C. siamensis* annually for reintroduction (Manolis 2017).

 Indonesia: The Siamese crocodile is currently known to occur in the Mahakam River system in East Kalimantan Province (Cox *et al.* 1993; Muin and Ramono 1994; Ross *et al.* 1998; Cox 2004; Kurniati *et al.* 2005; Stuebing *et al.* 2015). Unconfirmed reports suggest additional *C. siamensis* populations may also occur in Central Kalimantan Province (Ross *et al.* 1998). These are the only extant populations of *C. siamensis* outside of mainland Southeast Asia and consist of individuals that are genetically distinct from mainland conspecifics (Gratten 2003). The *C. siamensis* population in Lake Mesangat has been the focus of several ecological studies (Stuebing *et al.* 2015). Although crocodile habitat in the lake has suffered from past logging and wildfires (Chokkalingam *et al.* 2005), Lake Mesangat supports what may be the single largest *C. siamensis* population in any Range State (Platt *et al.* 2018). The False gharial (*Tomistoma schlegelii*) is also present in Lake Mesangat, making this the only currently known location where these two species of threatened crocodilians occur sympatrically (Stuebing *et al.* 2015; Platt *et al.* 2018).

Mark-recapture surveys conducted during 2010-2011 indicated that fewer than 30 individuals may be present, although a recent survey suggests this estimate is overly conservative (Platt *et al.* 2018). No hunting or trade of *C. siamensis* has been observed at Lake Mesangat, although local fishermen occasionally harvest crocodile eggs. Other threats include the incidental capture of crocodiles in fishing gear and disturbance due to illegal electro-fishing activities (N. Behler, unpubl. data). Parts of Lake Mesangat are owned by an oil palm company, which in 2010 entered into a partnership with a local foundation (Yayasan Ulin) to jointly manage this wetland (Rob Stuebing in litt.). However, about 70% of the wetland has been converted to oil palm production and water diversion continues to negatively alter hydrological conditions (Manolis 2017).

In 2016 at the behest of the local government, a multistakeholder forum was established to evaluate management options for Lake Mesangat and facilitate the designation of this biologically unique area as an Essential Ecosystem Area (Platt *et al.* 2018). Historically, *C. siamensis* occurred in Java (Ross 1990, 1992), although no recent information has been forthcoming regarding extant populations. Given the widespread loss of wetland habitats in Java, the continued survival of *C. siamensis* on the island seems unlikely. Historical reports of *C. siamensis* in Sulawesi remain unconfirmed (Platt and Lee 2000).



Figure 8. Siamese crocodile habitat (open marsh) at Lake Mesangat, Kalimantan, Indonesia.



Figure 9. Siamese crocodile habitat (closed-canopy swamp forest) at Lake Mesangat, Kalimantan, Indonesia.



Figure 10. Juvenile Siamese crocodile photographed during spotlight survey of Lake Mesangat, Kalimantan, Indonesia.

Laos: The first systematic field surveys for C. siamensis were undertaken between 2003 and 2008 (Thorbjarnarson et al. 2004; Bezuijen et al. 2006b; Cox and Phothitay 2008) and confirmed previous reports (Salter 1993; Sawathvong 1994) that many local populations had been extirpated and remnant populations were small, scattered, and fragmented. Intensive hunting in the mid-20th century, principally for skins and to supply living crocodiles to farms, appears to be the principle drivers of these declines (Stuart and Platt 2000; Bezuijen et al. 2013). The largest remnant populations in Laos occur in 8 river systems: Xe Champhone, Xe Banghiang, Xe Bangfai and Xe Xangxoy in Savannakhet Province, Xe Pian, Xe Khampho, Xe Kong in Attapu Province, and Xe Don in Salavan Province (Bezuijen et al. 2006b; Cox and Phothitay 2008; Bezuijen et al. 2013). Additionally, a small population consisting of at least two crocodiles was "rediscovered" in Khammouane Province of Central Laos in 2015 (Ziegler et al. 2015). Since 2003, nesting has been recorded in at least 6 sites, but evidence of successful recruitment (hatchlings) has been confirmed at only two sites (Bezuijen et al. 2013; Platt 2018). Most localities where C. siamensis occurs in Laos are community-controlled wetlands outside of the

national protected area system (Bezuijen *et al.* 2013; Platt 2012; Platt *et al.* 2014b).

Remnant C. siamensis populations in Laos are threatened by loss of wetland habitats, incidental capture in fishing nets, and egg collection (Platt 2012; Bezuijen et al. 2013). Intentional killing of large adult crocodiles is rare, but nonetheless occurs for a variety of reasons (Platt 2012). The only known captive population in Laos is at Ban Kuen Zoo, near Vientiane, where 500-1000 crocodiles are kept, many of which are probably hybrids (Phothitay et al. 2005; Cox et al. 2008; Platt 2012; Platt et al. unpubl. data). At least three factors are key to future C. siamensis conservation in Laos; 1) community-based conservation approaches outside of the national protected areas system, 2) habitat-level management of permanent and seasonal wetlands (rivers, lakes and ponds), and 3) protection of confirmed breeding sites. Community workshops were held in 2006 and 2007 to document local knowledge of crocodiles (Bezuijen et al. 2006a; Mollot et al. 2007), and in 2008 a community-based crocodile conservation project was initiated (Cox et al. 2008), which included preparation of a crocodile management plan for Savannakhet Province (Cox and Somvongsa 2008).



Figure 11. Floating peat mat used for nesting by Siamese crocodiles in an oxbow wetland (Savannakhet Province, Laos).



Figure 12. Siamese crocodile nest with eggs (Savannakhet Province, Laos).

A very successful community-based conservation program involving egg collection and head-starting of juveniles was implemented at several villages in Savannakhet Province (2008-2013) and continued until donor support was unexpectedly withdrawn for unspecified reasons (Platt *et al.* 2014b). A total of 65 head-started juveniles were returned to the wild in 2013-14, and recent (2018) surveys suggest high survival among the reintroduced crocodiles (Platt *et al.* 2014b; Platt 2018).



Figure 13. Villagers collecting a clutch of Siamese crocodile eggs as part of a community-based crocodile conservation program in Savannakhet Province, Laos. Eggs were incubated in the village (see Fig. 14), and hatchlings head-started and later released in natal wetlands.



Figure 14. An improvised incubation chamber used to successfully hatch wild-collected Siamese crocodile eggs in a community-based conservation program in Savannakhet Province, Laos.

• <u>Malaysia</u>: Smith (1919) reported a single specimen of *C. siamensis* from Peninsular Malaysia. The eastern and western coasts of Peninsular Malaysia previously supported extensive lowland wetland habitats contiguous with the wetlands of southern Thailand. Given this habitat connectivity the historic distribution of *C. siamensis* almost certainly extended southwards into Peninsular Malaysia.

There are no documented records from Sarawak or Sabah (Sebastian 1993). In 2005-2007, hatchling *C. siamensis* were exported from Thailand to farms in Sabah (source: UNEP-WCMC database).

- Myanmar: There are no recent records of C. siamensis in Myanmar (Thorbjarnarson et al. 2006). However, at least one historical reference suggests that C. siamensis formerly occurred in Myanmar (Garnier 1996). The area most likely to support a surviving population is along the Mekong River in eastern Myanmar. Unconfirmed local reports of crocodiles from the Mekong River in adjacent northern Laos (Salter 1993; Bezuijen et al. 2013) also suggest the range of C. siamensis perhaps once extended into Myanmar. The section of the Mekong River where C. siamensis might still occur in Myanmar (~200 km) is within the notorious "Golden Triangle", an area rife with illegal activity and under tenuous government control. Habitats along this river section (and where it enters northern Laos and Thailand) have been impacted by recent blasting to remove rapids and deepen the channel for boat traffic, and increasing shipping activity. Any remnant populations of C. siamensis that persist in this area are no doubt small and severely threatened.
- Thailand: Historically, C. siamensis was widely distributed in lowland regions of Thailand, but most populations have been extirpated as a result of direct persecution, habitat loss, and collecting to stock commercial crocodile farms (Platt et al. 2002). The critically endangered national status of C. siamensis in Thailand appears unchanged since the 1992 and 2010 CSG status reviews (Thorbjarnarson 1992; Simpson and Bezuijen 2010). Surveys since the early 1990s have confirmed several small populations of doubtful viability persisting in marginal habitats (Kreetiyutanont 1993; Ratanakorn and Leelapatra 1994; Ratanakorn et al. 1994; Platt et al. 2002; Temsiripong 2003; Kanwatanakid-Savini et al. 2012). One hatchling was discovered at Pang Sida National Park (PSNP) in 2002 suggesting the existence of a small breeding population (Temsiripong 2003).



Figure 15. Siamese crocodile nest in Kaeng Krachan National Park, Thailand.

A reintroduction project initiated by the Royal Thai Forest Service and the Crocodile Management Association of Thailand released 20 crocodiles at PSNP in 2005 and 2006 (Temsiripong 2001, 2006, 2007). Monitoring by ranger patrols and camera trapping detected few of the reintroduced animals (Temsiripong 2006, 2007), and additional crocodiles are slated for release in the near future (Manolis 2017). Spotlight surveys at Bueng Boraphet Wildlife Non-hunting Area found 8 adult *C. siamensis* (1.2-2.0 m TL) and plans have been approved to augment this small population with captive-bred, headstarted crocodiles (Manolis 2017).

Many thousands of Siamese crocodiles are held on crocodile farms in Thailand (Youngprapakorn et al. 1971; Suvanakorn and Youngprapakorn 1987; Getpech 2011). According to Getpech (2011), 552, 000 C. siamensis (or hybrids) were present on 799 farms in 2010. More recently, Manolis (2017) reported almost 1.2 million C. siamensis present on Thai farms in 2016. Crocodile farming (both C. siamensis and C. porosus) now accounts for approximately 1% of Thailand's agricultural income (Lepbenjakul et al. 2017). Hybridization between C. siamensis and C. porosus occurs and is bi-directional between males and females of the parent species (Lepbenjakul et al. 2017). Hybrid crocodiles (C. siamensis \times C. porosus) are fertile, and reportedly grow faster and produce higher quality skins than either parent species (Suvanakorn and Youngprapakorn 1987). Despite hybridization, a genetically diverse captive population of pure Siamese crocodiles is present on farms in Thailand and could serve as a critically important source pool for future reintroduction efforts (Lepbenjakul et al. 2017).

Vietnam: Vietnam appears to be the first Range State where C. siamensis has been extirpated and viable wild populations apparently no longer survive anywhere in the country. Early reviews (Cuc 1994; Cao and Jenkins 1998) indicated that populations had been severely depleted by massive habitat loss, intensive hunting, and capture for commercial crocodile farms. Surveys of Cat Tien National Park and U Minh Thuong Nature Reserve during 1999-2001 failed to locate crocodiles (Platt and Tri 2000; Stuart et al. 2002). Surveys of Ha Lam Lake (Phu Yen Province), where crocodiles were reputed to be abundant, detected only two individuals (Nguyen et al. 2005). Ha Lam Lake and the surrounding area has since been submerged beneath the Ba River hydroelectric dam. A re-introduction of 60 adults/ sub-adults to Bau Sau Lake in Cat Tien National Park was carried out in 2001-2004 (Polet 2002; Murphy et al. 2004), with at least one nest being produced in 2005. Regular monitoring indicated that adult mortality was high (at least 25% were killed in 2004 by local residents). Nonetheless, a visit to the park during July-August 2009 detected hatchlings and juveniles, confirming that successful breeding was continuing even in the face of persecution (J. Thorbjarnarson, pers. comm. 2010). The reintroduced population had increased to 100-150 individuals by 2010-2011 and contained a maximum of 80 non-hatchling crocodiles and 10-15 adults (Pahl 2012). Poaching remains

rampant in the park with crocodiles being hunted for local consumption (Pahl 2012). Tracks and feces of *C. siamensis* were found in Yok Don National Park in 2015 suggesting a small population (ca. <5 crocodiles) is present (Norwak *et al.* 2015). Over 1000 crocodile farms harboring 584,000 *C. siamensis* (and hybrids) are located in southern Vietnam (Jelden *et al.* 2008; Truyen 2011). Hybridization between *C. siamensis* and *C. rhombifer* is known to occur on many of these farms (Fitzsimmons *et al.* 2002; Jelden *et al.* 2008; Truyen 2011).

Conservation Summary

The global population of *C. siamensis* likely consists of 1000 or fewer mature individuals. The single largest known extant population probably occurs in Indonesia (Lake Mesangat, Kalimantan), although a rigorous assessment of this site is not yet available (but see Platt *et al.* 2018). Cambodia and Laos support significant remnant populations, but these are small, fragmented, and face a variety of threats. Nonetheless, wild populations in both countries are sufficient to provide a basis for recovery with appropriate and careful management (eg some populations will likely require augmentation to remain viable). Reintroduction of *C. siamensis* is an appropriate conservation strategy where suitable habitat is available but populations no longer exist, and mitigation of potential threats has been accomplished (Ilhow *et al.* 2015).

Crocodylus siamensis is well-represented in captivity and hence, not threatened with biological extinction. Over 1.6 million individuals are held on farms in Thailand, Cambodia and Vietnam (Temsiripong et al. 2004; Jelden et al. 2005, 2008; Manolis 2017; Manolis, pers. comm. 2018), and smaller numbers are maintained at zoos in Europe, North America and Asia. Captive populations represent a source of crocodiles for population augmentation and reintroduction provided the genetic identity of animals selected for release can be ascertained (Platt et al. 2004; Kanwatanakid-Savini et al. 2012; Platt 2012). Hybridization between C. siamensis and both C. porosus and C. rhombifer is apparently widespread among some captive populations (Chavananikul et al. 1994; Thang 1994; Jelden et al. 2008; Starr et al. 2009). Because hybrids cannot be distinguished based on phenotype, genetic screening is necessary to confirm species identity of any crocodiles selected for release (Fitzsimmons et al. 2002; Starr et al. 2009). Especially promising is a captive-breeding program currently underway at several zoos in the USA with the specific objective of producing crocodiles for eventual repatriation to Range States. To be assured of success, however, re-introduction programs must first address the complex suite of threats facing C. siamensis in the wild (Platt et al. 2004).

In 2005 and 2008, at the request of national management authorities, the Crocodile Specialist Group (CSG) conducted a review of *C. siamensis* in Cambodia and Vietnam to improve conservation and management of captive and wild populations (Jelden *et al.* 2005, 2008). Recommendations proposed by the CSG encompassed legislation and regulations, CITES compliance obligations, captive management, surveys and conservation initiatives, control of illegal trade, regional conservation initiatives and restocking options, and are contributing to current efforts by national agencies (Jelden *et al.* 2005, 2008). Similar CSG reviews for crocodile management (including *C. siamensis*) were previously conducted in Indonesia (Webb and Jenkins 1991a) and Thailand (Webb and Jenkins 1991b). In the latter country, the Crocodile Management Association of Thailand (CMAT) is attempting to initiate a reintroduction program for *C. siamensis* in several protected areas. A National Crocodile Management Plan that includes *C. siamensis* has also been prepared for Indonesia (PHPA 1997).

Priority Projects

High priority

- 1. Status surveys and implementation of Siamese crocodile conservation programs in Indonesia (Kalimantan): As Lake Mesangat harbors the single largest population of *C. siamensis* anywhere, there is an urgent need to establish some form of legal protection for this wetland, preferably by incorporating the site into the national system of protected areas. Population surveys followed by regular monitoring (perhaps based on aerial nest counts) would facilitate crocodile conservation efforts at Lake Mesangat by providing scientifically rigorous data on which to base management plans. Other, as yet unknown, populations of *C. siamensis* likely occur elsewhere in the Mahakam River Basin of East Kalimantan. Therefore, a province-wide population survey would strengthen conservation efforts for *C. siamensis* in Indonesia.
- 2. Implementation of crocodile management and conservation programs in Cambodia and Laos: These two countries harbor a number of globally significant C. siamensis populations. Unfortunately, most of these are small, highly fragmented, and threatened by a variety of anthropogenic activities. Because most populations of C. siamensis in Cambodia and Laos occur on village lands rather than within protected areas, efforts in these countries must rely heavily on community-based conservation programs. The Tonle Sap in Cambodia should figure prominently in any future conservation efforts. Tonle Sap is the largest freshwater wetland in Southeast Asia and historically supported a robust Siamese crocodile population. A large number of floating crocodile farms are present on the lake and offer a ready source of animals for reintroduction. Reintroduction of captive-bred offspring from facilities in Range States as well as North American and European Zoos would go far towards boosting recovery trajectories of many populations assuming prior mitigation of existing threats. Zoo-raised progeny would be especially valuable for reintroductions in Laos, which lacks a ready domestic source of captive-bred crocodiles. Management plans for both Cambodia and Laos have been drafted, but focus on a limited number of sites and face serious funding challenges. Securing sustainable, long-term funding to develop, initiate, strengthen, and expand these efforts is a major hurdle that must be overcome before effective

crocodile conservation programs can be implemented in either country. Both local stakeholder and government support at the national level are critical to ensuring Siamese crocodile populations are effectively protected over the long-term. Field efforts must be complemented by national and regional dialogue to address the illicit trade of wild crocodiles, particularly with Thailand and Vietnam.

- 3. Establish viable wild C. siamensis populations within the protected area network of Thailand: Thailand hosts what is arguably the most effective and well-developed protected area network of any Siamese crocodile Range State in Southeast Asia. As such, Thailand has the potential to spearhead global C. siamensis recovery efforts. Of further importance, a reservoir of genetically pure C. siamensis is present on commercial farms in Thailand that could serve as a ready source of crocodiles for reintroduction efforts. Although the potential for large-scale reintroductions of C. siamensis in Thailand is widely acknowledged, to date little progress has been made towards implementing such a program. A national reintroduction program with the ultimate objective of establishing viable wild populations in every protected area containing suitable wetland habitat is therefore warranted and would go far towards securing the global future of this critically endangered species.
- 4. **Dialogue between neighboring states**: Control of trade between neighboring Range States is difficult for any one country to unilaterally achieve. A dialogue process, perhaps through a regional working group under an appropriate body (eg ASEAN Wildlife Trade Initiative and/ or Mekong River Sub-regional CITES Working Group) to address regional issues and problems with *C. siamensis*, is considered an important action to control illegal trade.

Moderate priority

- 5. Strengthen links between conservation of wild populations and national crocodile farms: Crocodile farms in Thailand, Cambodia, and Vietnam are a significant potential resource for local conservation initiatives and could be lobbied for financial and technical support.
- 6. Clarify distribution and conservation status in marginal Range States: Status surveys and reviews of museum specimens are necessary to clarify the status of *C. siamensis* in Indonesia (including unconfirmed records from Sulawesi and Sumatra), Malaysia and Myanmar.
- 7. Maintain genetically pure stocks of *C. siamensis* in commercial crocodile farms: Most captive *C. siamensis* populations occur in large crocodile farms in Thailand, Cambodia and Vietnam, where hybridization with *C. porosus* and *C. rhombifer* is well-documented. Farms should be incentivized to segregate genetically pure *C. siamensis* of known origin and make these animals (or their offspring) available for conservation. Nevertheless, the genetic identity of farm-reared crocodiles must be ascertained through molecular techniques before any of these animals are released into the wild.

- 8. Develop zoo-based conservation-breeding programs in Asia, Europe and North America: A number of zoological gardens in Asia, Europe and North America exhibit crocodiles that are purported to be genetically-pure C. siamensis. Siamese crocodiles reproduce readily under zoo conditions (Magill 1982; Brazaitis and Abene 2008) and therefore seem an ideal candidate for an international zoobased conservation-breeding program with the objective of furnishing animals for reintroduction efforts in Range States. Zoo-based conservation breeding has the potential to produce large numbers of individuals within a relatively brief period. Furthermore, captive-bred crocodiles could provide much needed genetic diversification for small remnant wild populations in addition to providing founders for new populations. However, as stated earlier, molecular screening is necessary to insure the genetic integrity of any C. siamensis used in captive-breeding programs.
- 9. Establish a second wild population of Siamese crocodiles in Kalimantan, Indonesia: Currently, the only known wild population of *C. siamensis* in Indonesia occurs at Lake Mesangat in Kalimantan. In light of the tenuous conservation status of the Lake Mesangat population, serious consideration should be given to establishing an additional population in suitable habitat (ideally within a protected area) elsewhere in Kalimantan. Founder stock for any future reintroduction should be sourced from existing crocodile farms in Kalimantan to insure that only locally-adapted genotypes are released.

Acknowledgements

We acknowledge the valuable input of researchers who are no longer with us [Jack Cox (dec.), Charles Ross (dec.), John Thorbjarnarson (dec.)], Jenny Daltry and Charlie Manolis. Deb Levinson, Kent Vliet and Ruth Elsey are thanked for assistance with obtaining literature, and Lewis R. Medlock reviewed an early draft of this account.

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